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HISTORICAL PERCHLORATE LEVELS IN THE LAS VEGAS WASH AND LAKE MEAD

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Introduction

The recent discovery of perchlorate (CLO_4^-) in the water supplies of California, Nevada and Utah has generated a considerable interest in the investigation of occurrence, fate and transport, and the development of potential treatment technologies for the removal of this contaminant from water supplies. Perchlorate is of environment concern because it is known to affect the thyroid gland by inhibiting the uptake of iodine anion into the gland. However, accurate information on the toxicological and health effects of perchlorate on humans is limited. Perchlorate is a highly water soluble and a non-volatile substance. These properties increase its motility and the persistence in the natural environment. The current regulations on drinking water standards do not strictly regulate perchlorate in water supplies. However, California has set an advisory standard of 18 ppb.

The groundwater contamination of perchlorate in Nevada is a direct result of the manufacturing of rocket fuel in the valley. Ammonium perchlorate (NH_4ClO_4), which is a major component of rocket fuel and explosives had been manufactured by two industries located within the Basic Management Complex (BMI) in Herderson, Nevada for several decades. Manufacturing of perchlorate started at one industry in 1958 and continued until this plant was destroyed by an explosion in 1988. Production of perchlorate at the second plant has been carried out from 1945 to the present. During this period, considerable amounts of contaminated wastewater had been discharged into several unlined ponds located within their premises. As a result of continuous leaching of perchlorate contaminated water into the underlying aquifer, the groundwater in the vicinity of the industrial complex is contaminated. Monitoring of groundwater within the contaminated site and the adjacent surface water bodies have been carried out by several agencies. Groundwater obtained from some of these monitoring wells has contained perchlorate concentrations as high as 3,700 ppb.

The major water bodies in the Las Vegas Valley are the Las Vegas Wash and Lake Mead. The Las Vegas Wash (LVW) is located at the lower section of the valley basin and drains into Lake Mead and Colorado river, which are the primary drinking water supply of Las Vegas, Phoenix and California. The LVW receives stormwater runoff, groundwater infiltration as well as treated effluents from the three wastewater treatment plants located in the valley. During the past, the LVW did not support a steady water flow to reach the lake, except during heavy rainfalls. However, with the development of the valley increased the discharge of effluents into the LVW, which sustained a steady flow into the lake. The contaminated groundwater from the BMI Complex leaches into LVW and ultimately flows into Lake Mead.

For the implementation of long-term remedial measures, it is important to investigate the fate and transport of perchlorate in the Las Vegas Valley. There is limited information known about the variation of the perchlorate concentration in the Las Vegas Wash, and fate of the pollutant once it enters Lake Mead. The specific objectives of the research are as follows:

1. Document past perchlorate levels in the Las Vegas Wash and Lake Mead.
2. Use data to validate fate and transport models for perchlorate in the valley.
3. Support decision making associated with decreasing the uncertainty and the risk associated with the consumption of perchlorate contaminated water supplies.

Methodology

The Clark County Sanitation District (CCSD) of Las Vegas has an archive of frozen water samples collected from several points along the Las Vegas Wash and Lake Mead, which date back to 1993. These samples were collected as part of a program to monitor the quality of the effluent discharged to the Las Vegas Wash by the wastewater treatment plants. This research was possible due to the availability of these samples. The locations of the major sampling points along LVW and Lake Mead are shown in Figures 1 and 2. In the lake the samples were collected at epilimnion, mesolimnion and hypolimnion layers. The sampling points for the LVW include points both upstream and the down stream of the contaminated site, which gives the opportunity to investigate the perchlorate loading from the contaminated site. The availability of sampling points at different depths at the lake provides the opportunity to study the transport of perchlorate within the lake.

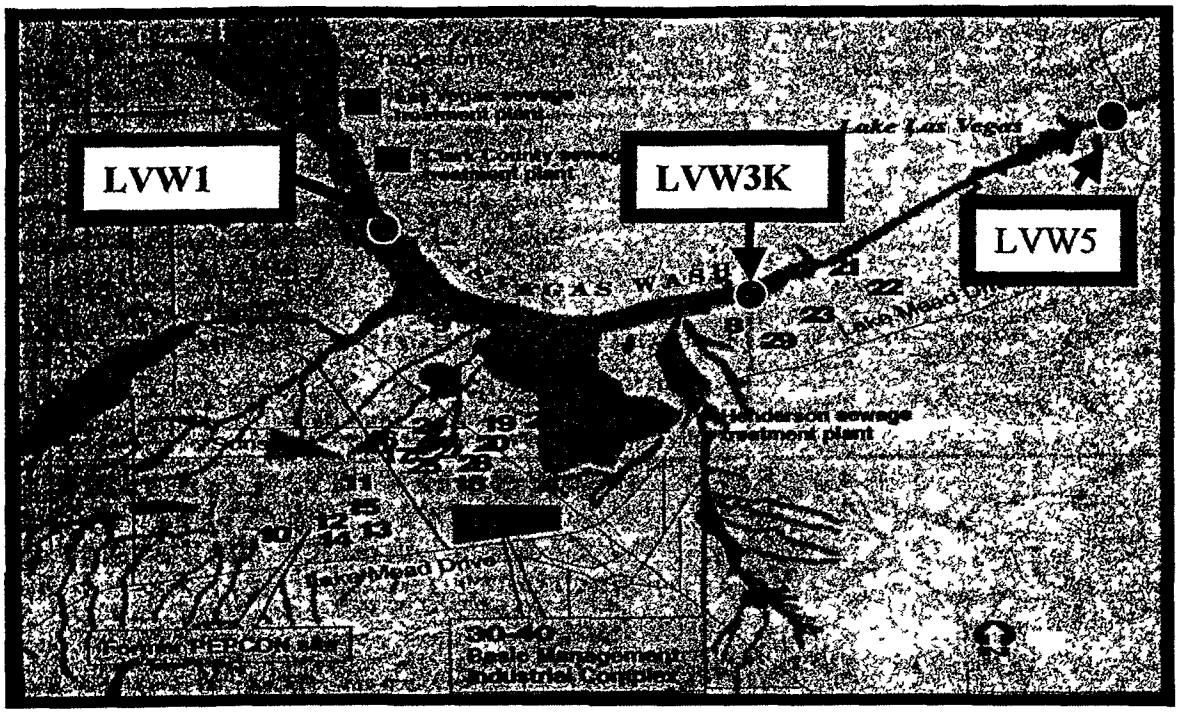


Figure 1: Water Sampling Locations of Las Vegas Wash
(Source: Modified from the LVRJ)

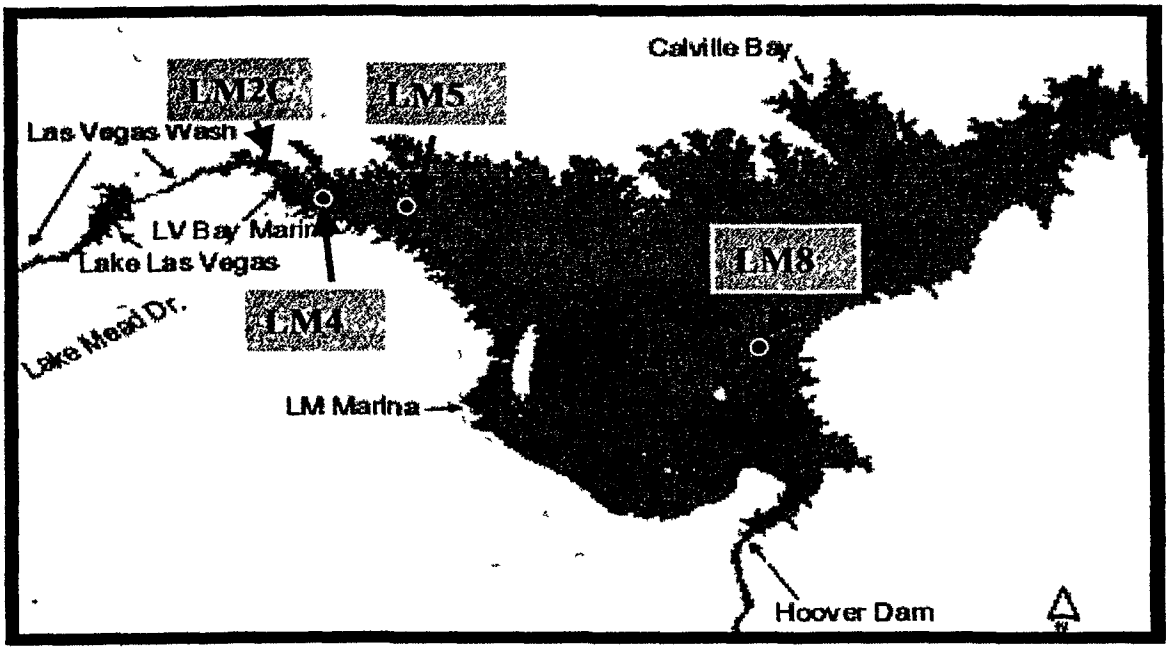


Figure 1: Water Sampling Locations of Lake Mead

Experimental Procedure:

- The frozen samples were thawed for three days.
- Aliquots were taken from the thawed samples for analysis.
- The samples were analyzed for perchlorate by Ion Chromatography at the University of Nevada -Las Vegas Environmental Engineering Lab.

Results

The analysis of the frozen water samples shows that perchlorate in the upstream of the contaminated site is relatively low. In the LVW1 sampling point which is located upstream of the contaminated site, perchlorate concentrations average 15.4 ppb from 1993 to present. In addition, perchlorate concentration at this point remained constant during the period analyzed. The perchlorate levels in the LVW increases by a factor of 50 once it reaches the downstream portion of the contaminated site. The perchlorate concentrations in the LVW3K sampling point, averaged about 400 ppb in 1993, and gradually increased to about 800 ppb by year 1995, and have stabilized around this level (Figure 4). Notice that the flow of the wash for the same period did not change significantly. The LVW5 sampling point located further downstream from LVW3K had an average perchlorate concentration of 550 ppb in 1993, and gradually increased to about 700 ppb by year 1995. The perchlorate levels at this point have stabilized around 750 ppb after year the 1995. The slight lower concentration (compared to LVW5) at this point may be attributed to the dilution of the stream by groundwater.

The approximate perchlorate loading into Lake Mead was calculated based on the average daily flow data available for the LVW5 location. In 1993 the perchlorate loading was around 200 kg/day, and this gradually increased to 400 kg/day by the year 1996. The loading rates have reached a steady level of 400 kg/day after 1996. The perchlorate levels for LVW locations are shown in Figures 3-6.

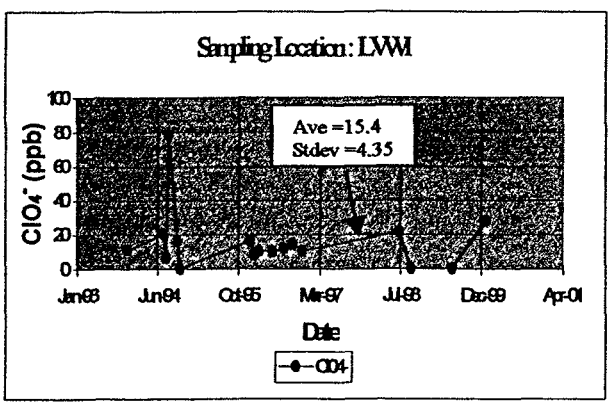


Figure 3: Perchlorate in the LVW1 (Upstream)

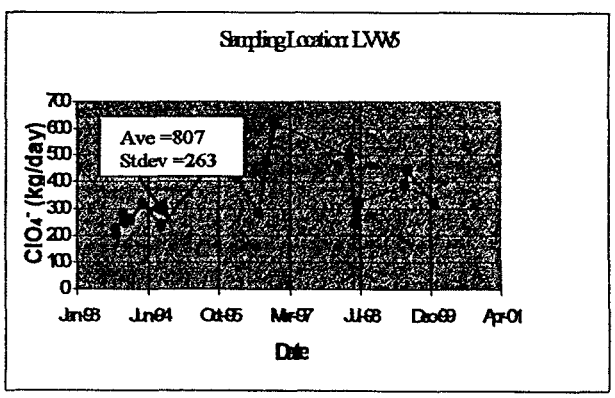


Figure 4: Perchlorate in the LVW3K (downstream)

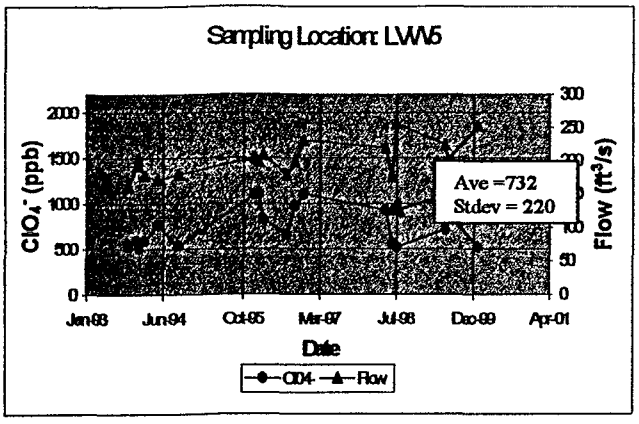


Figure 5: Perchlorate in the LVW5 (Upstream)

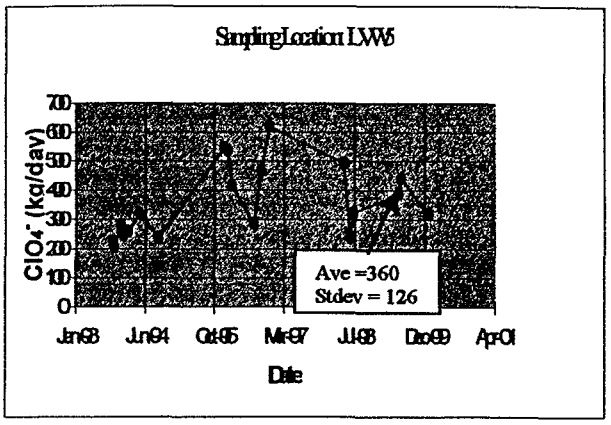


Figure 6: Perchlorate Loading into the lake

The samples taken from the Las Vegas Bay, which is the entry point of the LVW into the lake show that perchlorate is quickly diluted to concentrations around 100-200 ppb. Another observation is that perchlorate levels in the interior sections of the lake are around 10-15 ppb. The variations of perchlorate concentrations with time in the sampling points in the same lake are illustrated in figures 7 to 16.

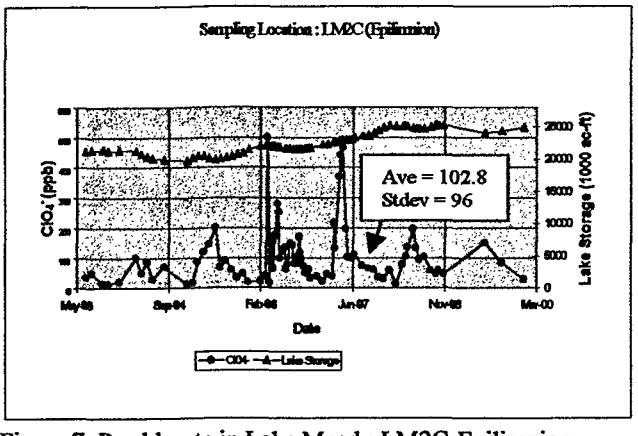


Figure 7: Perchlorate in Lake Mead : LM2C-Epilimnion

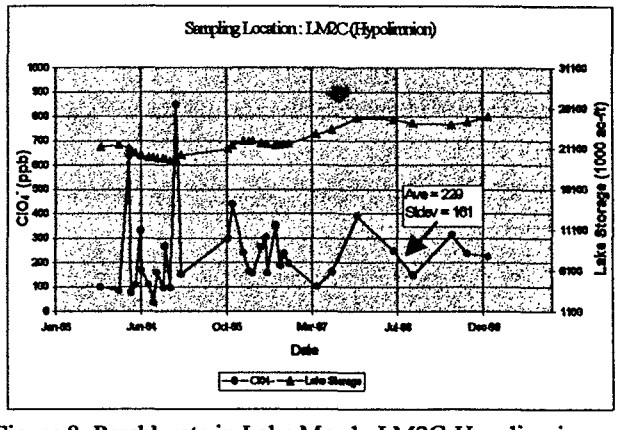


Figure 8: Perchlorate in Lake Mead : LM2C-Hypolimnion

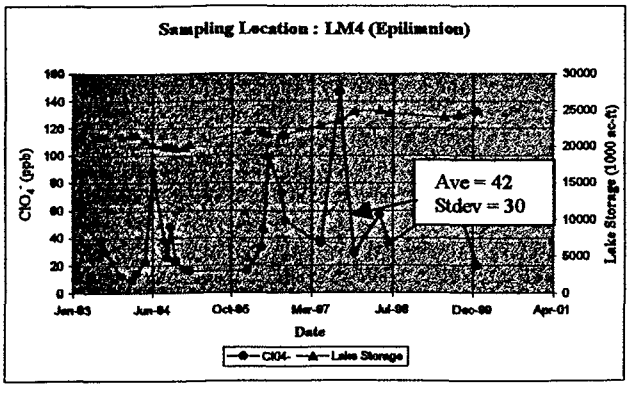


Figure 9: Perchlorate in Lake Mead : LM4-Eplimnion

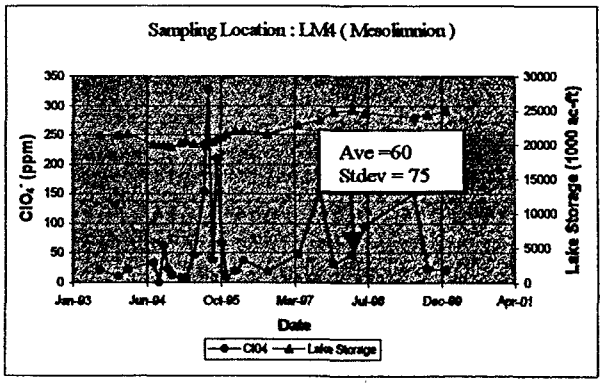


Figure 10: Perchlorate in Lake Mead : LM4-Mesolimnion

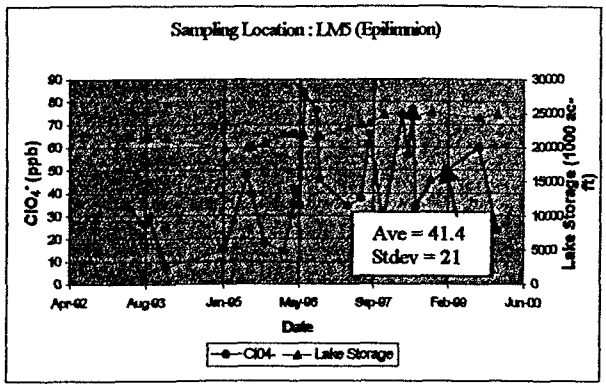


Figure 11: Perchlorate in Lake Mead : LM5 -Epilimnion

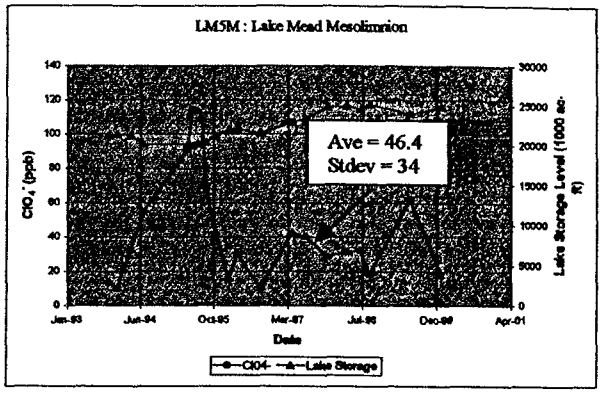
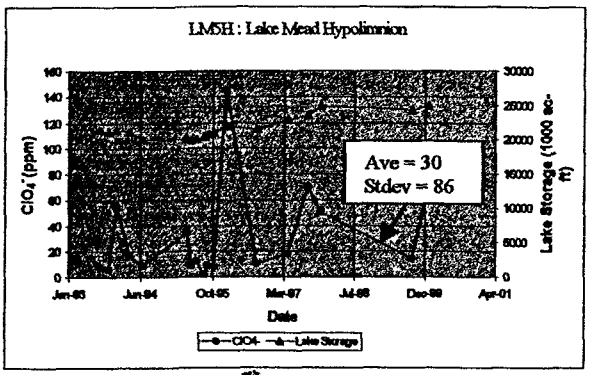


Figure 12: Perchlorate in Lake Mead : LM5 -Mesolimnion



Fugure 13: Perchlorate in Lake Mead : LM5 - Hypolimnion

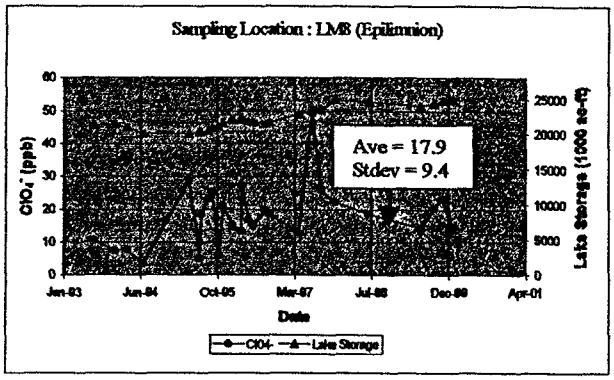
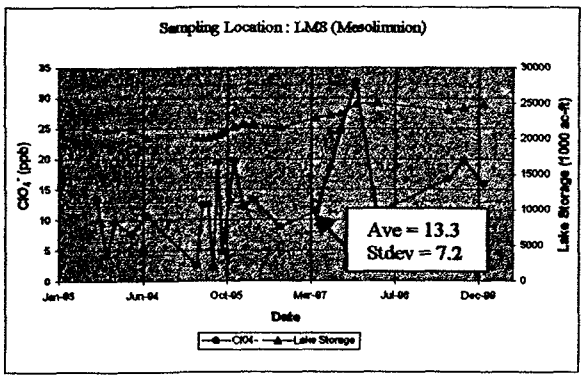


Figure 14: Perchlorate in Lake Mead : LM8 - Epiliomnion



Fugure 15: Perchlorate in Lake Mead : LM8 - Mesolimnion

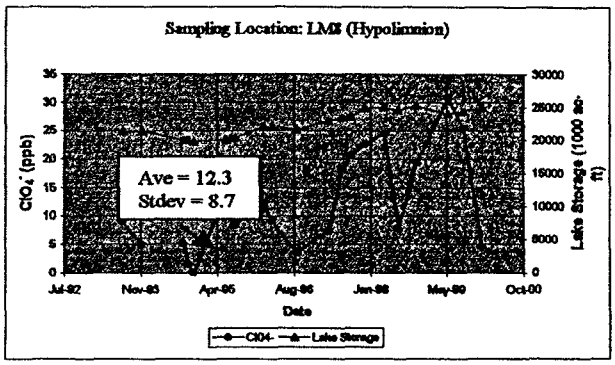


Figure 16: Perchlorate in Lake Mead : LM8 - Hypoliomnion

Table 1 Average Perchlorate Levels at the Sampling Locations

Lake Layer	Sampling Locations			
	LM2C	LM4	LM5	LM8
Epilimnion	102.8 ppb	42 ppb	41.4 ppb	17.9 ppb
Mesolimnion	229 ppb	60 ppb	46.4 ppb	13.3 ppb
Hypolimnion	-	129 ppb	30 ppb	12.3 ppb

Basic statistical analyses were carried out for the perchlorate concentrations in the epilimnion, mesolimnion and hypolimnion layers of Lake Mead samples. The analyses indicate that the perchlorate levels in the sampling points of the Las Vegas Bay Area (LM2C and LM4C) are significantly different from each other at epilimnion, mesolimnion and hypolimnion layers. The perchlorate levels in these samples gradually increased with lake depth. The spatial variation of perchlorate with depth gradually decreased in the interior sections of the lake. There was little variation difference (along the depth) among the samples collected at the interior LM8 sampling location. Table 1 shows the average perchlorate level for the Lake Mead samples. Notice that the concentration of perchlorate increased with the depth at the sampling points closer to the discharge of the LVW (LM2C & LM4). However, the exact opposite was observed in the interior sample points (LM5 & LM8).

Since the Las Vegas Wash is the main perchlorate source for the lake, this might indicate that the flow of the Wash could be within the mesolimnion and hypolimnion layers of the lake at the initial stages, and later may flow within the epilimnion layer before it mixes into the lake. However, further investigation is needed to study the flow of LVW inside the lake. Further analysis will be carried out to investigate the movement of perchlorate within the lake by evaluating the existing data and data being collected. The perchlorate data will be correlated to other water quality and flow data for the same locations. The researchers also intend to study the prevalence of the pollutant in the lake and LVW sediments, plants and other forms. This would provide additional information on the flow of the LVW inside the lake and the transport and fate of perchlorate within the lake.

Conclusions

The following conclusions can be drawn from the data available at this stage:

- Perchlorate contamination in the Las Vegas Wash and Lake Mead has been documented back to 1993.
- The data indicate that the perchlorate levels in the Wash increased after 1994 to an average of 800 ppb by the year 1995, and later stabilized around this level.
- The high perchlorate levels of the Wash are quickly diluted to small concentrations after entering Lake Mead.
- In points further from the Wash perchlorate concentrations are below 20 ppb, although sporadic higher concentrations have been detected in some samples.
- Analyses of the perchlorate samples of the lake indicate that the flow of the Las Vegas Wash is within the mesolimnion and the hypolimnion layers within the Las Vegas Bay area.